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FOREST PEST MANAGEMENT

BIOLOGICAL EVALUATION
R2-91-03

OVERWINTERING EGG POPULATIONS OF A PINE SAWFLY, NEODIPRION AUTUMNALIS ON PONDEROSA PINE NEAR GILLETTE, WYOMING

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United States Department of Agriculture
Forest Service
Forest Pest Management
Denver, Colorado

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ABSTRACT

In 1990, a number of outbreaks of the pine sawfly, Neodiprion autumnalis, were reported in eastern Wyoming and western South Dakota. Generally east of Gillette in Wyoming, defoliation in 1990 was severe at the center of the infestation and decreased to light defoliation at more than 25 miles north and south of the center. The center was located south of the Chalk Hills near Cabin Canyon, about 15 miles southeast of Gillette. At the most heavily damaged sites, virtually all 1989 and older foliage was stripped from trees and much of the 1990 foliage also was consumed.

Overwintering egg populations were surveyed near Gillette, Wyoming, to assess potential for defoliation in 1991. Sample branches (generally 1 1/2 - 2 feet in length) collected at 10 or 15 ft. above ground at three sample sites contained averages of between 0.1 and 2 infested shoots per branch, 0.7-19 infested needles per branch, and 9-286 eggs per branch. Egg densities were lowest at the center of the infestation and highest 25 miles out. Average number of eggs per individual needle were between 13 and 16, with means of 0.1-3 sawfly colonies per branch that contained averages of 77 to 95 eggs per colony. Eggs were laid on all ages of foliage at site 3 (farthest from infestation center) and followed a distribution pattern similar to the distribution of different ages of remaining foliage. All eggs were laid on 1990 foliage at sites 1 and 2, where little older foliage remained. Only 1-4 needles per sawfly egg are available at sites 2 and 3, whereas 29 needles are available per sawfly egg at the infestation center (site 1).

The sawfly population appears to be collapsing at the infestation center and defoliation can be expected to be light to moderate near site 1 in 1991. Defoliation is expected to be heavy to severe up to 25 miles away from the infestation center (sites 2 and 3) with mass starvation of larvae likely. High mortality from starvation and other factors, such as parasites and predators, may contribute to collapse of the population in 1992, except perhaps for the extreme ends (north and south) of the outbreak area. Tree mortality is not likely to result from defoliation alone, but drought stress and subsequent infestation by Ips bark beetles may cause small losses. Insecticide application should be considered to protect high value sites or where private landowners want to preserve the aesthetic appearance of their forested lands; however, no action is needed for most instances because trees can recover following collapse of the sawfly population. Release of parasitic insects to augment the natural enemy population is unlikely to be effective because the sawfly population is already beginning to collapse naturally and availability may be problematic.

INTRODUCTION

In late July and early August 1990, many private landowners in eastern Wyoming and western South Dakota contacted various county, state, and federal offices concerning heavy defoliation of ponderosa pine (Pinus

ponderosa Dougl. ex Laws.) by a pine sawfly, Neodiprion autumnalis (Smith) (Hymenoptera: Diprionidae). In Wyoming, approximately 84,000 acres were heavily to severely defoliated in a north-south ridge in eastern Campbell County near Gillette, and additional pockets were reported from Linch, Osage, and the Wyoming-Montana border (Fig. 1). Affected land included about 63,000 acres of privately-owned land, 13,500 acres of federal land (Bureau of Land Management), and 7,300 acres of State of Wyoming land. In South Dakota, outbreak areas included approximately 1,500 acres between Spearfish and Belle Fourche, 300 acres at Ft. Meade, 2,000 acres in the northeast corner of Wind Cave National Park and adjacent private property, and windbreaks near Camp Crook. In many areas, older needles were almost totally consumed and many current-year needles were clipped to within 1-5 inches of the branch. Affected sites tended to be areas of widely-spaced trees with poor growth on dry sites with poor soils. The entire region has been experiencing a drought since 1988.

Neodiprion autumnalis was recently described as a species separate from the N. fulviceps complex (Smith and Wagner 1986). Biologically, N. autumnalis is distinguishable by the fall emergence of adults and the presence of eggs from fall until hatch during spring or early summer. The life history described for a sawfly species at Willits, California, is suspected to be that of N. autumnalis (Dahlsten 1961). A univoltine life cycle was described whereby adults emerge from mid-October to early November. The female deposits eggs in rows of slits she cuts in the needle tissue and eggs remain there over winter until mid-March or April. Young larvae feed in groups on needles of the outermost branch tips, initially feeding on the edges of needles. Older larvae completely devour the needles. There are five feeding instars and a sixth non-feeding instar. Larvae drop to the ground in late May or early June to spin cocoons in the duff and litter or as deep as two inches into the soil. Pupation occurs within the cocoon during late September or early October. Larval development in South Dakota and Wyoming in 1990 was observed later than that reported for California, with feeding damage being apparent throughout July and larvae dropping to the ground in late July and early August. Differences in development between these locations might be caused by differences in weather conditions, particularly temperature.

The purposes of this evaluation were to estimate sawfly populations near Gillette using samples of overwintering eggs, determine whether control measures may be needed in 1991, and obtain biological information pertaining to N. autumnalis eggs that could be useful for assessing populations and potential damage levels for future years and infestations.

METHODS

Branch samples were collected from ponderosa pines at three privately-owned sites near Gillette, Wyoming, on January 10-11, 1991 (Fig. 2). Site 1 was located near the center of the infestation at T48N, R70W, Sec. 23, NE 1/4 of SW 1/4. Site 2 was located about 3 miles north of site 1, at T48N, R70W, Sec. 1, S 1/2 of SW 1/4. Site 3

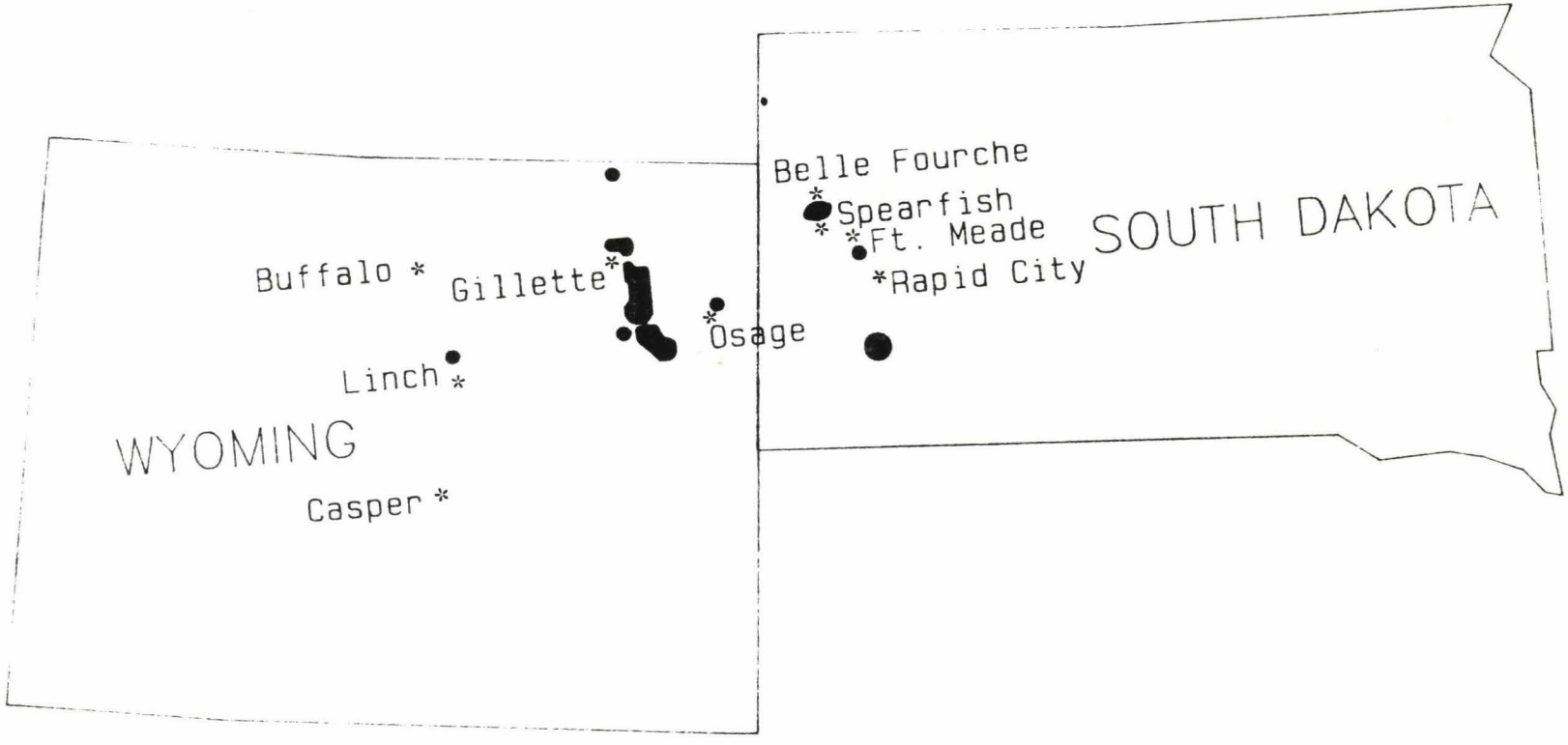

Fig. 1. Distribution of pine sawfly outbreaks in South Dakota and Wyoming.

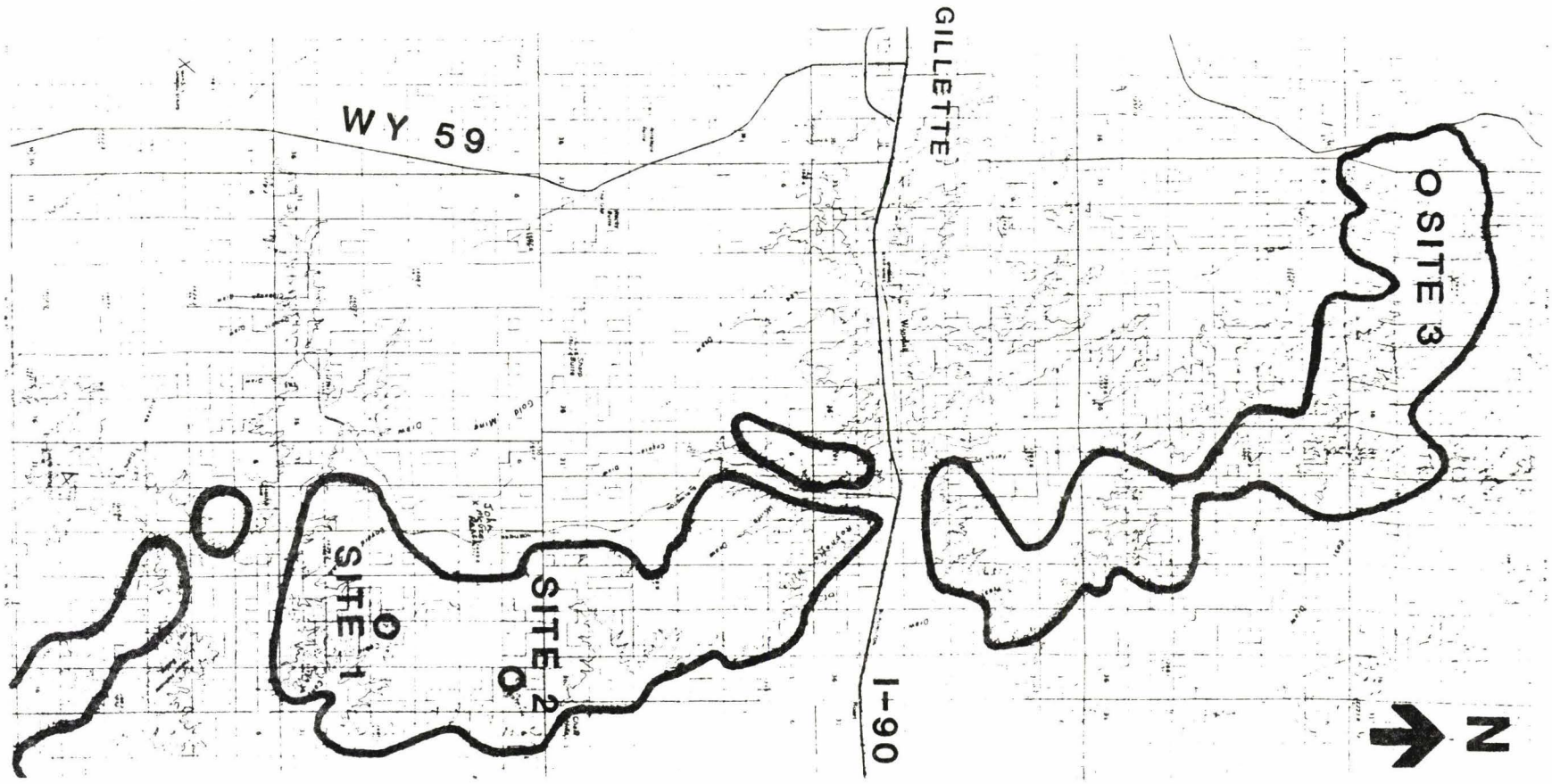

Fig. 2. General outline of sawfly infestation and location of sample sites near Gillette, Wyoming.

was at the Wildwood Christian Camp located about 12 miles north of Gillette, at T52N, R71W, Sec. 30, N 1/2 of NW 1/4. From each sample tree, four branches approximately 1 1/2 - 2 ft. in length were removed using a pole-pruner from a height of about 10 ft. at sites 1 and 2 and 15 ft. at site 3 (approximately mid-crown level). Each of the four branches was collected from a different side of the tree. Fifteen trees were sampled at each site.

Sample branches were examined to determine numbers of needles by year of growth (1990, 1989, and 1988 or older--most trees had 4 years of growth), number of needles with sawfly eggs by year of growth, total number of shoots and number of shoots with sawfly eggs, number of sawfly eggs per colony, and number of egg colonies per branch. Needles were counted if at least 2 in. remained; many of the 1990 needles had been partially consumed. A shoot was defined by the presence of a bud and all the needles between it and a branch fork or node. Each brown spot along the edge of infested needles was counted as the presence of a sawfly egg with the exception of the most proximal oviposition slit (thought to sever the resin canal). A sawfly colony included a group of needles in close proximity to each other (separated by not more than a few needles) that contained sawfly eggs. Maximum and minimum values and means were determined for each variable at each site. Values also were calculated for percent of shoots and branches that contained eggs, percent of remaining foliage by year of growth, total needles remaining per sawfly egg, percent of branches without needles by year of growth, percent of branches with sawfly eggs by year of needle growth, number of shoots per sawfly colony, mean number of needles per sawfly colony, mean number of sawfly eggs per colony, mean number of needles per egg for branches containing eggs, mean number of eggs per total needles per branch, and mean number of eggs per infested needle.

RESULTS

Data on needle abundance and pine sawfly abundance and density are summarized in Tables 1-4.

Needle abundance reflected the general levels of defoliation that occurred during summer 1990 at the three sample sites; sites 1 and 2 were severely defoliated, and site 3 was heavily defoliated. Remaining foliage at site 3 was almost 1 1/2 times that of site 1, and remaining foliage at site 2 was intermediate (Table 1). Almost all the remaining foliage was 1990 growth at sites 1 and 2, and almost half (49%) of remaining foliage was 1990 growth at site 3. Most branches at sites 1 and 2 were completely stripped of 1989 and older needles. At site 3, 20% and 33% of branches were completely stripped of 1989 and 1988 or older needles, respectively.

Abundance of pine sawfly eggs was greatest at site 3, intermediate at site 2, and least at site 1, showing an inverse pattern to the general trend in infestation levels from the 1990 population (Table 2). Infested shoots averaged between 0 and 2 per branch, and ranged as

Table 1. Values of needle abundance for ponderosa pine branch samples collected at 15 ft. in January 1991 near Gillette, Wyoming.

BRANCH VARIABLE	SITE 1 (n = 59)	SITE 2 (n = 59)	SITE 3 (n = 60)
Branch length (in.)			
Minimum	11	9	15
Maximum	25	35	36
Mean ± SD	17.4 ± 3.4	20.2 ± 5.1	21.8 ± 4.8
No. 1990 needles			
Minimum	55	42	19
Maximum	750	848	1081
Mean ± SD	260.6 ± 144.3	298.5 ± 169.6	180.6 ± 156.5
No. 1989 needles			
Minimum	0	0	0
Maximum	117	82	270
Mean ± SD	4.9 ± 17.4	4.3 ± 12.8	50.5 ± 69.5
No. 1988 & older needles			
Minimum	0	0	0
Maximum	56	14	1064
Mean ± SD	1.7 ± 8.7	1.2 ± 3.2	138.2 ± 228.5
No. needles/branch			
Minimum	55	42	64
Maximum	755	851	1580
Mean ± SD	267.2 ± 143.7	304.0 ± 171.4	369.3 ± 320.7
No. shoots/branch			
Minimum	3	3	2
Maximum	49	34	66
Mean ± SD	11.5 ± 7.5	11.2 ± 7.0	11.8 ± 10.0
% branches w/o needles			
1990	0	0	0
1989	76.3	67.8	20.0
1988 & older	93.2	81.4	33.3
All	0	0	0

Table 2. Values of pine sawfly egg abundance for ponderosa pine branch samples collected at 15 ft. in January 1991 near Gillette, Wyoming.

BRANCH VARIABLE	SITE 1 (n = 59)	SITE 2 (n = 59)	SITE 3 (n = 60)
No. shoots with eggs			
Minimum	0	0	0
Maximum	2	6	15
Mean ± SD	0.1 ± 0.4	0.9 ± 1.3	2.0 ± 2.4
% shoots with eggs			
All samples	1.0	8.2	17.1
Mean/branch	2.1 ± 9.3	10.3 ± 15.1	21.4 ± 20.5
No. needles with eggs			
Minimum	0	0	0
Maximum	10	38	125
Mean ± SD	0.7 ± 2.2	5.9 ± 8.8	19.4 ± 25.1
No. eggs/1990 needles			
Minimum	0	0	0
Maximum	131	486	1389
Mean ± SD	9.2 ± 28.8	84.5 ± 120.2	161.2 ± 223.1
No. eggs/1989 needles			
Minimum	0	0	0
Maximum	0	0	432
Mean ± SD	0.0 ± 0.0	0.0 ± 0.0	50.1 ± 103.6
No. eggs/1988 & older needles			
Minimum	0	0	0
Maximum	0	0	1087
Mean ± SD	0.0 ± 0.0	0.0 ± 0.0	75.2 ± 202.6
No. eggs/all needles			
Minimum	0	0	0
Maximum	131	486	1544
Mean ± SD	9.2 ± 28.8	84.5 ± 120.2	286.5 ± 331.7
No. sawfly colonies			
Minimum	0	0	0
Maximum	2	7	20
Mean ± SD	0.1 ± 0.4	1.0 ± 1.5	3.0 ± 3.6

Table 3. Values of pine sawfly eggs per individual infested needle for ponderosa pine branch samples collected at 15 ft. in January 1991 near Gillette, Wyoming.

BRANCH VARIABLE	SITE 1 (n = 59)	SITE 2 (n = 59)	SITE 3 (n = 60)
No. eggs/individual infested needle			
for all needles:			
Minimum	2	1	1
Maximum	25	41	46
Mean ± SD	12.9 ± 6.2	14.5 ± 7.1	14.8 ± 6.6
for 1990 needles:			
Minimum	2	1	1
Maximum	25	41	46
Mean ± SD	12.9 ± 6.2	14.5 ± 7.1	15.7 ± 7.2
for 1989 needles:			
Minimum	--	--	2
Maximum	--	--	30
Mean ± SD	--	--	14.5 ± 6.0
for 1988 & older needles:			
Minimum	--	--	2
Maximum	--	--	33
Mean ± SD	--	--	13.2 ± 5.6

Table 4. Values of pine sawfly population density for ponderosa pine branch samples collected at 15 ft. in January 1991 near Gillette, Wyoming.

BRANCH VARIABLE	SITE 1 (n = 59)	SITE 2 (n = 59)	SITE 3 (n = 60)
% branches with eggs			
1990	10.2	47.5	71.7
1989	0.0	0.0	31.7
1988 & older	0.0	0.0	25.0
All	10.2	47.5	81.7
No. needles/colony			
Minimum	1	1	1
Maximum	10	18	30
Mean ± SD	6.0 ± 3.2	5.8 ± 3.6	6.4 ± 5.3
No. eggs/colony			
Minimum	3	8	2
Maximum	131	229	474
Mean ± SD	77.1 ± 42.6	83.9 ± 52.3	95.5 ± 81.8
Total No. shoots/ No. colonies	97.3	11.0	3.9
Total No. needles/ No. eggs	29.2	3.6	1.3
Needles/egg for branches with eggs			
Minimum	1.6	0.6	0.2
Maximum	3.9	18.4	40.4
Mean ± SD	2.7 ± 0.8	3.3 ± 4.0	2.7 ± 5.9
Eggs/needle for all branches			
Minimum	0.0	0.0	0.0
Maximum	0.6	1.7	4.0
Mean ± SD	0.0 ± 0.1	0.3 ± 0.4	0.9 ± 0.9
% of total eggs laid on:			
1990 needles	100.0	100.0	56.3
1989 needles	0.0	0.0	17.5
1988 & older	0.0	0.0	26.2
% of total needles by age			
1990 needles	97.5	98.2	48.9
1989 needles	1.8	1.4	13.7
1988 & older	0.6	0.4	37.4

high as 15 shoots infested per branch at site 3. An average low of 2% of shoots were infested with sawfly eggs at site 1 and an average high of 21% of shoots were infested at site 3.

Branches contained an average of 9, 84, and 286 eggs at sites 1, 2, and 3, respectively. The number of needles per branch infested with eggs averaged 0.7, 6, and 19 at sites 1, 2, and 3, respectively. The number of eggs laid per needle generally averaged between 13 and 15 (Table 3). Most eggs were deposited along one edge of a needle, but a few rare instances of eggs being laid on both sides of a needle were noted.

Sawfly eggs were laid on all ages of foliage at site 3, but only on 1990 needles at sites 1 and 2 (Tables 2 & 4). At site 3, the percentages of eggs laid by year of needle growth were similar to the relative abundance of needles in the different age classes. At sites 1 and 2, little foliage older than 1990 growth was available for oviposition.

The number of sawfly colonies per branch averaged from 0.1-3, but ranged as high as 20. For the different sample sites, the number of needles per egg colony averaged around 6, and the number of eggs laid per colony averaged between 77 and 95. A number of unusually large colonies were noted particularly at site 3 that might actually have been 2 colonies that were laid so close together that they could not be separated visually. One colony was present for every 97, 11, and 4 shoots at sites 1, 2, and 3, respectively.

Egg density in relation to available foliage was lowest at site 1 and high at sites 2 and 3 (Table 4). There were 29 needles available per sawfly egg at site 1, but only 4 and 1 needles available per egg at sites 2 and 3, respectively. Since these values were calculated from overall needle and egg counts at each site, they do not reflect variations in distribution from branch to branch or tree to tree. Thus, means were calculated for branches that contained eggs, and they averaged about 3 needles per egg per infested branch at all three sites, but the range of individual branch values was much greater at site 3 than at site 1, with site 2 intermediate.

DISCUSSION

Some egg deposition characteristics at the Gillette location were similar to those reported for the Willits and Mt. Shasta (Site 1) populations in California, suggesting that these populations may indeed represent the same species; however, there were a few differences in egg distribution. Stark and Dahlsten (1965) reported a preference for oviposition on current year's foliage with 58-67% being deposited there and 30-40% being deposited on 1-year-old foliage at Mt. Shasta, California. For heavily to severely defoliated trees sampled near Gillette, Wyoming, the distribution of eggs generally followed the distribution of remaining foliage. At sites 1 and 2, all eggs were laid on 1990 foliage, but there was little older foliage present. Eggs were laid on all ages of foliage at site 3.

The mean number of eggs laid per needle was slightly lower at Gillette (13-15) than for ponderosa pines at Willits (17.1) and Mt. Shasta (19.5) in California (Dahlsten 1966). The mean number of eggs per needle appeared to decrease with increasing needle age (current year: 20.0; 1-year: 16.7; 2-year: 13.5) at the Mt. Shasta site, but was not statistically significant (Stark & Dahlsten 1965). Mean number of eggs per needle showed a similar trend at site 3 for different ages of foliage at Gillette, but differences in values were small (current year: 15.7; 1-year: 14.5; 2-year & older: 13.2). The Gillette values also were similar to those found at Ft. Meade in South Dakota (Pasek, 1991).

The number of eggs laid per colony were similar for the Gillette, Ft. Meade, and California populations and probably represent the full compliment of eggs of a given female, provided disturbance does not occur during egg-laying. Dahlsten (1961) estimated that a female could lay between 60 and 80 eggs, and average number of eggs per tip were 61.4 and 80.9 at Willits and Mt. Shasta, respectively (Dahlsten 1961, 1966). Dahlsten assumed one sawfly colony per tip, but sometimes more than one colony per tip was present at Gillette and counted separately. The means for number of eggs per colony at Gillette sites (77-95) were generally higher than for Ft. Meade sites (60-94). The highest mean number of eggs per colony at both locations was found at sites with the highest egg density (Gillette site 3 and Ft. Meade site 1) and was likely the result of a number of instances of coalescence of colonies.

Because N. autumnalis prefers to feed on older foliage, the 1990 foliage that was left by larvae feeding during 1990 will become a primary food source for larvae feeding during 1991. However, where 1989 and older foliage was essentially stripped in 1990 and much of the 1990 foliage also was consumed, total available foliage suitable for feeding by pine sawfly larvae will be greatly reduced in 1991. Based upon the numbers and densities of sawfly eggs present in the overwintering population, starvation is likely to occur, especially at sites 2 and 3, during 1991 (following heavy to severe defoliation). No figures have been documented as to how many needles an average larva consumes during the course of its development, but it is certain to be more than the 1-4 needles available per egg. A slightly higher number of needles may actually be available per feeding larva because of some mortality of eggs and first-instar larvae. Larvae that run out of food on a given branch or tree exhibit wandering behavior in search of food, and can readily be seen crawling up and down tree trunks and across the ground (Dahlsten 1961). This behavior can be expected in the 1991 population at many sites near Gillette, particularly for later instars. At site 1, the low egg numbers and density in relation to what little foliage remains indicates that the sawfly population is collapsing there. This population collapse can be expected to continue to spread outward from the infestation center in 1992.

In the absence of artificial control measures, defoliation can be expected to be low to moderate at the center of the infestation (site 1), moderate to heavy at 3 miles from the population center (site 2),

and severe at 25 miles from the population center (site 3). Although no areas beyond those defoliated in 1990 were sampled, the infestation is likely to spread somewhat to the north and south in 1991 relative to 1990 (spread is limited to the east and west by an absence of host material). Although defoliation levels can be expected to be heavy to severe in most areas (except the centermost and outermost portions of the infestation), tree mortality directly resulting from this pine sawfly species (or closely related species) has not been reported even after complete defoliation of older needles (Dahlsten 1966). Apparently the presence of enough uneaten current-year needles is sufficient to sustain the trees under normal circumstances. The current drought affecting defoliated trees in eastern Wyoming will contribute additional stress; a small percentage of trees might die under this condition, but extensive tree mortality is not anticipated.

Pine sawfly populations typically collapse following one or two years of epidemic levels as a result of mortality from a combination of parasites, predators, disease, starvation, and other natural causes, such as adverse weather conditions. Because of the high reproductive potential of females, mortality of 95% of the sawfly population (from egg to adult) is necessary just to maintain population levels (Dahlsten 1967). Small increases in mortality above 95% contribute to rapid decline of an infestation. The high larval population densities observed at the center (site 1) of the Gillette infestation in 1990 likely contributed to high mortality of larvae and pupae due to starvation or disease spread, and may have reduced fecundity of surviving females. Areas with high population densities in 1991 (sites 2 and 3) can be expected to show a similar rapid decline following the 1991 feeding period. The population might continue at high levels into 1992 along the perimeter of the infestation (extreme north and south ends), where populations will not likely to be as high in 1991.

Sawfly mortality varies through the stages of development and at different times during the course of an infestation. Such factors are difficult to assess for a given population without extensive, on-going study. However, mortality trends can be expected to generally follow that reported by Dahlsten (1967) from life table studies of the Mt. Shasta, California population. Total mortality during the 1-year study was 99.2% and contributed to a downward trend of 31% in the egg population the following year.

Egg parasitism is expected to be low in Wyoming; it was 5% in the Mt. Shasta study. No evidence of egg parasitism was detectable in the overwintering egg samples from Gillette; however, parasitism generally is not noticeable until eggs begin to swell in spring. Egg mortality resulting from cold temperatures and competition from other needle-feeding insects was high at Mt. Shasta, but is not expected to be a significant factor at Gillette due to a differing climate, lower elevation, and absence of competing insects.

Larval mortality can be significant just following hatch (25% at Mt. Shasta) caused by inability to emerge from the egg pocket due to excessive drying, failure to establish at a feeding site, entrapment

in water droplets, being dislodged from the tree, and other adverse weather factors. Drying of egg pockets could be a significant factor at Gillette because of drought conditions. Mortality of feeding larvae (2nd-5th instars) typically is low, with some predation occurring. Parasitism that occurs during larval stages does not become apparent until the cocoon stage (i.e., feeding continues after the larva becomes parasitized). Disease was not detected in the Mt. Shasta larval population but is common in related sawfly species; it is not known whether diseases are present in the Gillette population. Anticipated larval mortality due to starvation is likely to be greatest toward the end of the feeding period. Additional mortality likely will result after larvae drop from trees to the ground (43% of prespinning larvae or 16% of original population at Mt. Shasta).

The cocoon stage is especially vulnerable to attack by a number of parasites and predators, particularly insects and small mammals. Additional mortality can result from disease (Beauveria bassiana (Bals.) identified at Mt. Shasta). Total loss of cocoons was 93% at Mt. Shasta, but may not be this high in Wyoming. Of 135 pupae obtained near site 1 (collected as 5th and 6th instar larvae on July 27, 1990), 35% emerged as sawfly adults; few parasites emerged. Adult sawflies emerged from about 40% of cocoons collected during late summer 1990 in Butte County, South Dakota (personal communication, Rich Dorset, South Dakota Division of Forestry). However, no estimate of predation was determined at either location. Predators consumed 33% of cocoons at Mt. Shasta. Parasite adults emerged from 6% of the Butte County cocoons and another 8% represented unhatched cocoons that likely contained spring-emerging parasites. This is much lower than the rate of parasitism of cocoons (43%) at Mt. Shasta. Mortality due to disease or unidentified causes were similar for Butte Co. and Mt. Shasta populations; 5% of unhatched cocoons were covered with fungus and 15% died of undetermined causes in the Butte Co. sample. The relatively low parasitism found in Wyoming and South Dakota likely contributed significantly to the development of epidemic populations in these areas and contributed to perpetuation of the outbreak beyond one year. Because the Wyoming populations appear to be collapsing already primarily due to starvation (and possibly disease), augmentation of the parasite population is unlikely to add significantly to decline of the populations in 1991 and 1992, even if active pine sawfly outbreaks could be located elsewhere so that parasites can be collected for release in Wyoming.

ALTERNATIVES

Alternative 1: Insecticide Application - Foliage can be sprayed aerially or using ground equipment with an appropriately registered chemical insecticide, such as carbaryl (Sevin) or malathion. Application should be timed to coincide with the presence of less than full-grown larvae (2nd to 4th instar), which are likely to occur in June to early July in Wyoming, depending upon weather conditions.

Alternative 2: Biological Control - Parasitic insects can be released to augment the natural enemy complex. Availability of parasitic insects for release can be problematic.

Alternative 3: Do Nothing - Accept defoliation as a natural phenomenon. Pine sawfly populations typically decline rapidly within a couple years following the initiation of an outbreak and most trees recover.

RECOMMENDATION

No action in needed at the center of the outbreak where population decline is occurring naturally.

Since most of the affected area contains non-timber producing sites, the cost of applying insecticides can not be justified in relation to the resource values (wildlife, recreation, aesthetics, etc.). The do nothing alternative may be best for most of these sites that are located on public lands. Parasitic insects could be released if an adequate supply can be produced, but the effort is not likely to produce a high benefit because the sawfly population is already beginning to collapse and parasite establishment requires time.

Insecticide application should be considered for high value sites, such as recreation and historical sites, where protection of aesthetic character and shading is important. Private landowners who want to protect their trees from defoliation for primarily aesthetic reasons and can afford to spray, should determine whether a high population exists before proceeding. This can be based upon visual observations of eggs or larvae. The Campbell County Weed and Pest Control District and Wyoming State Forestry offices can be contacted for assistance in making this determination. Relatively small, isolated areas (a few to several hundred acres) that have high sawfly densities also can be appropriate sites for insecticide application to reduce spread of the outbreak.

Insecticide application also may be an appropriate alternative where trees weakened by pine sawfly defoliation have a high probability of subsequent infestation by other insects that can directly cause tree mortality, such as pine engraver beetles (Ips). However, small pockets of tree mortality are not expected to significantly impact resource values. Placement of several pheromone traps to collect emerging Ips adults in the vicinity of infested trees might be a better alternative to reduce spread of the beetles in and around the area.

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